A RESOURCE UNIT ON PLANT TAXONOMY FOR A JUNIOR HIGH SCHOOL SCIENCE CLASS

A Field Report

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by

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TABLE OF CONTENTS

CHAPTER PAGE

LIST OF FIGURES

CHAPTER I

INTRODUCTION

I. PROBLEM

Statement of the problem. The purpose of this field report was to prepare a resource unit on plant taxonomy for use by junior high school science teachers.

Educational significance. There is at the time of this writing a definite lack of suitable material available to science teachers in the field of plant taxonomy at the junior high level. Although some teachers have had training in plant identification and classification, others have not been adequately prepared. One of the major aims of this resource unit was to provide the teacher with adequate information and materials from which a unit of study, suitable to local school conditions, could be developed.

A study in plant taxonomy at the junior high level can serve the following purposes. (1) It can help the student in preparation for high school biology by developing an understanding of basic principles of plant structure and functions. (2) The study of plants in the field can help the student become accustomed to working with living materials. (3) A study of plant identification by use of keys will aid the student in developing the ability to fol-

low specific instructions. (4) The identification of plants in the field will provide the student the opportunity to observe them in their natural habitat. (5) The identification of plants by their correct names and being able to fit them into their proper classification will give the students a greater appreciation of the natural world about us. (6) The study of plant taxonomy can lead some students to a lifelong hobby.

Justification of the resource unit. In view of studies made by various conferences and curriculum committees on biological education in the decade of 1950-1960 and continuing on into the sixties, it was evident that there was a definite need for an integrated program in the biological sciences. This program would attempt to present a sequence of biological concepts, appropriate to the grade level, beginning with kindergarten and continuing through the twelfth grade.[1]

There is a need, however, for considerable research at this point to determine the level of maturity at which various concepts can be successfully introduced. Numerous curriculum texts and articles were surveyed. It was discussed with science teachers and the science consultant of

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[1]Paul Hurd, Biological Education in American Secondary Schools 1890-1960 (in Biological Sciences Curriculum Study Bulletin Series, ed. Frances C. Harwood. Baltimore: Waverly Press, Inc., 1961), pp. 231-241.

the Iowa Department of Public Instruction. The conclusion was that it would be feasible to teach a unit in plant taxonomy at a lower grade level than in the customary tenth-grade biology class. It was further concluded that the junior high school would be the proper placement for such a unit. The exact grade level would depend upon the organization of the science program within the school.

Delving into various junior high school science texts numerous science curriculum guides, it was found that virtually no such unit was available in the field of plant taxonomy. So, the conclusion was that there was a definite need for a resource unit in plant taxonomy at the junior high level.

Procedure followed. In curriculum texts, the term pre-planning is often referred to. Of the several types mentioned, the two most often referred to were "teaching units" and "resource units." This lead to some further investigation as to the difference between the two types of units.

It was found that the text, Education for Social Competence, provided a clear and concise differentiation between the two types of units.

A resource unit differs from a teaching unit in that:

1. It is made for teachers rather than student use;
2. It contains many more suggestions than can be used by any one class;

3. It covers a broad area from which materials can be drawn for the study of specific topics or problems;
4. It gives a number of possibilities for achieving the same objective; and
5. It is not organized as a classroom teaching guide.[1]

A number of science curriculum guides were surveyed for both senior and junior high school. Several conferences also were held with the science consultant for the Iowa Department of Public Instruction. It was felt from these investigations that the treatment of beginning plant taxonomy was inadequate. Especially lacking was a simple yet adequate plant identification key that could be used and understood by junior high science students. The key included in this resource unit was an attempt to provide, in part, such a key.

The supply of suitable textbook in beginning plant taxonomy is somewhat limited. However it was found that Taxonomy of Flowering Plants by Porter[2] presented a concise and complete coverage of the field of taxonomy. This text is used in beginning courses of plant taxonomy at the college level. It was this text that was used as the primary guide in the outline and description of the field of plant taxonomy and in the description and terminology of the

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[1] I. James Quillen and Lavons A. Hanna, Education for Social Competence (Chicago: Scott, Foresman and Company, 1948), p. 186.

[2] C. L. Porter, Taxonomy of Flowering Plants (San Francisco: W. H. Freeman and Company, 1959).

flowering plants. Bold's Morphology of Plants[1] and Non-Flowering Plants by Shuttleworth and Zim[2] were used as the main guides for the description and terminology of the non-flowering plants. In construction of the key, Plant Families--How to Know Them by Jaques[3] and Plants of Iowa by Conard[4] served as very useful guides.

Two texts were especially helpful in arriving at the objectives which the user of the resource unit should strive. These were Education for Social Competence[5] and Permanent Learning.[6]

Teaching Science in Today's Secondary Schools[7] provided valuable help in outlining the evaluation program for the unit.

The families and species included in the key were

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[1]Harold C. Bold, Morphology of Plants (New York: Harper and Row, 1957).

[2]Floyd Shuttleworth and Herbert S. Zim, Non-Flowering Plants (New York: Golden Press, 1967).

[3]H. E. Jaques, Plant Families--How to Know Them (Dubuque: Wm. C. Brown Company, 1949).

[4]Henry S. Conard, Plant of Iowa (seventh edition; Grinnell: The Author, 1958).

[5]Quillen and Hanna, op. cit., p. 65.

[6]W. H. Lancelot, Permanent Learning (New York: John Wiley and Sons, Inc., 1944), pp. 21-28.

[7]Walter Thurber and Alfred Collette, Teaching Science in Today's Secondary School (Boston: Allyn and Bacon, 1964).

selected as being representative of the common ones found in Iowa with the exception of a few aquatic species along the eastern and western boarders of the state.

Taxonomy of Flowering Plants[1] contained a very useful section on field and herbarium methods.

Definition of terms. There are two terms which should be differentiated. These are botany and plant taxonomy. Botany is that branch of science that studies all aspects of plant life. Plant taxonomy is the branch of botany that deals primarily with the identification and classification of plants.

Organization of the field report. The remaining part of this field report is organized into a review of the literature, objectives of the unit, an outline of the area of plant taxonomy, a suggested evaluation program and suggested materials and references related to plant taxonomy.

The field report is concluded with a brief summary chapter.

II. REVIEW OF THE LITERATURE

The literature that relates to this unit has been divided into two general areas for the purpose of this

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[1]Porter, op. cit., pp. 40-45.

review. The first to be considered is that which is concerned with curriculum and methods. The second area of consideration is that which deals specifically with plant taxonomy. A brief summary of the literature of these two areas will be presented here. The attempt has been to discuss the literature other than that which has been considered in previous sections of this report.

Literature on resource units. Leonard has set forth in his book, Developing the Secondary School Curriculum, some characteristics that a resource unit should have. In summary they are as follows:

1. It is prepared for teacher, not pupil use.
2. It is organized around a central problem.
3. The unit contains more material than can be used in one teaching unit.
4. Suggestions for goals, activities, references and classroom materials are contained in a resource unit.[1]

The components of a resource unit are outlined by Richardson and Cahoon in their text on Methods and Materials for Teaching General and Physical Science.[2] The essential

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[1] J. Paul Leonard, Developing the Secondary School Curriculum (New York: Rinehart and Company, 1946), p. 461.

[2] J. Richardson and G. Cahoon, Methods and Materials for Teaching General and Physical Science (New York: McGraw-Hill, 1951), pp. 13-15.

components are as follows:

A. Scope of unit and topics
   1. Important general concepts and principles are presented.
   2. Important applications are made.

B. Procedures and activities
   1. Laboratory - types
      a) Experiments
      b) Demonstrations
      c) Projects
      d) Field trips
   2. Lecture - discussion
      a) Lecture sessions
      b) Discussion groups
      c) Reports
   3. Study procedures
      a) Problems
      b) Drills
      c) Homework
      d) Individual help
   4. Evaluations

C. Teaching materials
   1. Visual materials
   2. Auditory materials

3. Bulletin boards and blackboards
4. Supplementary materials
    a) Books
    b) Periodicals
    c) Pamphlets

Writing in Education, Guy Wagner outlined what schools are doing in the way of developing resource units. He lists a number of trends that are taking shape in the development of the more recent units. Briefly, they are as follows:

1. Resource units are most prevalent in the social studies and in the sciences.
2. Resource units are set up in terms of initiatory, developmental and culminative activities.
3. The unit may have an introductory page suggesting how to utilize the resource unit in preparation of a teaching unit.
4. In recent units, pictures and drawing have been helpful in clarifying the context.
5. The trend is toward emphasis on development of concepts rather than just the acquiring of facts.
6. The resource unit is designed as a flexible guide for developing a teaching unit.
7. With the present trend toward unit teaching, it is important to have a file of current information as well as reference type materials included in the

resource unit.[1]

Quillen and Hanna have clearly differentiated between a teaching unit and a resource unit. The main difference is that a resource unit is intended for use by the teacher to aid in the developing of a teaching unit on a given subject.[2]

These references set forth the basic trends concerning resource units, their use and construction. It was the opinion of the author that these are representative of the literature available at the time of this writing.

Literature on plant taxonomy. Flowers, A Guide to Familiar American Wildflowers by Zim and Martin provides an excellent colored pictorial guide to the common wild flowers of the entire United States.[3]

Plant Families and How to Know Them by Jaques lists all the major families and keys them out to genera within each family.[4] This is very helpful when confronted with a number of entirely unfamiliar plants. Using the same

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[1]Guy Wagner, "What Schools are Doing Developing Resource Units," Education, LXXXIII (December, 1962), 62-63.

[2]Quillen and Hanna, loc. cit.

[3]Herbert S. Zim and Alexander C. Martin, Flowers, A Guide to Familiar American Wildflowers (New York: Simon and Schuster, 1950).

[4]H. E. Jaques, Plant Families and How to Know Them (Dubuque: Wm. C. Brown Company, 1948).

general approach, Cuthbert has written two guides to help identify wild flowers. One deals with the spring flowering plants,[1] and the other deals with the fall flowering plants.[2]

Gray's Manual of Botany[3] provides a complete coverage of the plants of North America. It lists and keys all the plants of the North American continent. It is an advanced reference work not intended for the beginning student of plant taxonomy. Also in this same category is the New Brittian and Brown Illustrated Flora of the Northeastern States and Adjacent Canada[4] by Gleason.

For the student, the Botany[5] merit badge pamphlet by the Boy Scouts of America provides a wealth of information on plant collecting and suggests projects for beginning collectors.

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[1]Mabel Jaques Cuthbert, How to Know the Spring Flowers (Dubuque: Wm. C. Brown Company, 1948).

[2]Mabel Jaques Cuthbert, How to Know the Fall Flowers (Dubuque: Wm. C. Brown Company, 1948).

[3]M. L. Fernald, Gray's Manual of Botany (New York: American Book Company, 1950).

[4]H. A. Gleason, New Brittian and Brown Illustrated Flora of the Northeastern States and Adjacent Canada (New York: 1952).

[5]Robert F. Lane, Botany (New Brunswick: Boy Scouts of America, 1941).

Non-Flowering Plants[1] by Shuttleworth and Zim provides an excellent introduction to the study and classification of the fungi, ferns, algae and mosses. It contains very fine color illustrations to help in the identification of the various plants. It would be useful to both the student and the teacher as a field guide.

Plants of Iowa[2] by Conard provides comprehensive coverage of the common trees, shrubs, ferns and most of the cultivated plants found in Iowa. It is complete key requiring the flower in most cases for positive identification.

Weeds of the North Central States[3] is a well illustrated paperback book that keys and describes the common weeds of the north central states, which includes Iowa. Another useful manual in this area is How to Know the Weeds[4] by Jaques. It is a spiral bound paperback that divides the weeds into the various families according to their common names.

Writing in The American Biology Teacher, A. J. Sharp

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[1]Floyd S. Shuttleworth and Herbert S. Zim, Non-Flowering Plants (New York: Golden Press, 1967).

[2]Henry S. Conard, Plants of Iowa (seventh edition; Grinnell: The Author, 1958).

[3]F. W. Slife (ed.), Weeds of North Central States (Urbana: University of Illinois, 1960).

[4]H. E. Jaques, How to Know the Weeds (Dubuque: Wm. C. Brown Company, 1959).

sets forth some of the responsibilities as well as opportunities which the taxonomist has. He reminds us that the taxonomist must bear part of the responsibility for maintaining plant resources for the expanding population. The taxonomist must help recreate man's awareness and appreciation of the dependence which we have on plants for food, shelter and drugs. Lastly, the plant taxonomist has a responsibility for the preserving of areas of natural plant populations and to encourage young people and amateur plant collectors to use these areas for educational and training programs in the future.[1]

Norman Russell discusses some of the understandings that should be taught in modern taxonomy. The role of taxonomy in biology as a whole should be understood, as well as the basic nature of classification. The student should understand the importance of naming and classifying in many areas other than just the plant kingdom. He should also have some knowledge of the history and the various approaches to taxonomy if he is to fully appreciate the scientific matter of the subject. In conclusion, the author believes that a student of taxonomy should understand his universe and develop a philosophy of life.[2]

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[1]A. J. Sharp, "Responsibilities and Opportunities of the Taxonomist Today," The American Biology Teacher, XXIV (February, 1962), 81-83.

[2]Norman Russell, "Teaching Modern Taxonomy," The American Biology Teacher, XXVII (December, 1965), 89-91.

A. C. Hamon suggests, in an article in The Science Teacher, that the use of dichotomous keys is often taught with the student not really understanding the function of a key. The student should understand that the key is merely an artificial means of learning to identify plants and it has certain limitations. Hamon suggests that the student be given a chance to construct a key to be used in classifying and identifying a variety of some ordinary objects such as nails or screws.[1]

Writing in The Instructor, Charles Finsley offers some suggestions for constructing a dichotomous key. The key should be kept as simple as possible. It should use characteristics that divide the material into two clear-cut parts and then ask the same two or three questions about each part. The article also gives two examples of a simple key, one for plants and another for insects.

The author focuses attention on some additional values to be gained from the use of a key. It broadens the student's vocabulary, strengthens the powers of observation and teaches the use of binomial system of naming plants. Lastly, logical reasoning can be taught and practiced through the use of a dichotomous key.[2]

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[1] A. C. Hamon, "Understanding a Key," The Science Teacher, XXXI (March, 1964), 63.

[2] Charles Finsley, "Key to Identification," The Instructor, XXVI, No. 2 (October, 1966), 110-111.

III. OBJECTIVES

These are the objectives of a resource unit on plant taxonomy:

1. To develop an understanding of the principles of taxonomy through the study of plants.
2. To develop an attitude of appreciation for the natural flora of the world around us.
3. To develop interests in the different areas of botany by the gaining of new knowledge and understanding in the area of plant identification and classification.
4. To acquire abilities and skills in observation and logical reasoning through proper use of a dichotomous key.

CHAPTER II

A RESOURCE UNIT FOR THE TEACHING OF PLANT TAXONOMY

I. THE AREA OF PLANT TAXONOMY

Introduction. Plant taxonomy has generally two aims: (1) to identify all plants, and (2) to arrange the plants into some sort of classification that will show their true relationship to each other.[1]

Taxonomy consists of several interrelated fields. The field of systematic botany encompasses morphology, physiology, ecology and genetics. The taxonomic system is the field that deals with the actual classification and arrangement of the plants into the various groups based on the facts gathered through systematic botany. Nomenclature is the method of naming the plants in accordance with the rules set forth by the International Code of Botanical Nomenclature. The last field making up the science of plant taxonomy is the documentation of plants. This includes the preservation of the type specimens, the standard of comparison for new plants.[2]

Taxonomy is one of the oldest of all sciences, dating

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[1] C. L. Porter, Taxonomy of Flowering Plants (San Francisco: W. H. Freeman and Company, 1959), p. 3.

[2] Ibid., p. 5.

back to Theophratus (370 - 287 B.C.), a pupil of Plato and Aristotle. In his History of Plants he described some five hundred species and classified them into four groups: herbs, undershrubs, shrubs and trees. This system did not necessarily show the true relationship of the plants.

Most of the early classification of plants dealt with plants having medicinal purposes, as exemplified by the works of Dioscalides, a military physician under Emperor Nero of Rome. During the early part of the seventeenth century, a group of German botanists revived an interest in taxonomy and made the first attempt to utilize binomial system of nomenclature.

The natural or phylogenetic system now used attempts to show the true relationship of plants to one another by grouping them into taxa according to their genetic and evolutionary sequence. Perhaps the name most often associated with early taxonomy is Carolus Linnaeus. His publication of Species Plantarum in 1753 initiated the binomial system of nomenclature which is used now. Also, it serves as the starting point for our present-day system of priority for the naming of the higher plants.

Asa Gray was probably the leading taxonomist during the early period of taxonomy in America. He was professor of botany at Harvard and was the original author of Gray's Manual of Botany. A student of Asa Gray, Charles Bessey,

was another early taxonomist of note. He originated a phylogentic system based on the Ranales (Buttercups) as the basic or most primitive group of plants from which the other order evolved. It is his system that is basically used in present-day classification. Bessey published his system in 1915. Two more modern classifications of the plant kingdom were made by Tippo in 1942 and by Bold in 1956. The changes were mainly to raise some of the taxon to higher rank.

Outline. The following is a broad outline of the field of plant taxonomy. It is intended to aid the teacher by providing the basic information necessary to teach a unit in plant taxonomy.

The outline is organized under the following main headings:

I. Nomenclature
II. Description and Terminology of Flowering Plants
III. Description and Terminology of Non-flowering Plants
IV. Field and Herbarium Methods

I. Nomenclature
   A. The binomial system
      1. The scientific name of a plant consists of two parts: (1) the generic name, and (2) the specific epither.
      2. The scientific name is determined by rules

adapted by the International Code of Botanical Nomenclature.

3. The first of the two parts is the generic name. It is always a singular noun in the nominative case and always begins with a capital letter.

4. The second part is the specific epithet. It is a descriptive word used to characterize the species and is a noun in the possessive case that is not capitalized.

B. The order

1. The major taxon or group immediately superior to the family and consists of related families.

2. The name is formed by adding ales to the stem of an included generic name. For example, the order Liliales is formed by adding ales to the genus Lilium which includes the lilies.

C. The family

1. The major taxon or group of related genera.

2. The name is formed by adding acea to the stem of an included generic name.

D. The authority

1. The person or persons who originally describes and names a plant is known as the authority of the name.

2. The authority is indicated by either a standardized abbreviation or written out following the scientific name.

E. The principle of priority

1. The principle of priority means names of plants that are published and accepted first take priority over names published later for the same plant. This becomes the valid name of a particular plant.
2. Names that are published subsequently for the same taxon become synonyms for that plant.
3. Botanists have agreed that the starting point for the system of priority be Linnaeus' Species Platarum published in 1753.

F. The type method

1. In order to stabilize the concepts of taxon from species upward through orders, botanists have adapted the type method.
2. The type method requires the author of a certain species to designate a certain specimen or acceptable substitute as the type of that species. This specimen then becomes the nomenclature type used as the standard of comparison when fixing the name to a given plant.
3. The nomenclature type for a genus is the species on which the generic name is based.

Likewise, the type for the family is the genus on which the family name is based as is the ordinal type the family on which the ordinal name was based.

4. In case of accidental destruction or loss of the original specimen on which the name was fixed, a system of designated substitutes has been devised. Briefly, they are as follows:

   a) Holotype: The original type specimen designated by the author at the time of publication of the name.

   b) Lectotype: A specimen selected from the original material studied by the author to serve as a holotype.

   c) Neotype: A specimen selected to serve as type when all material upon which the name was based is missing. A lectotype always has precedence over a neotype.

G. A summary of taxa used in classification

1. The following classification is applied to Poa pratensis, Kentucky Bluegrass:

   Kingdom - Plant

   Division - Embryophata

   Class - Monocotyledoneae

   Order - Poales

Family - Poaceae

Genus - Poa

Species - Poa pratensis (scientific name)

H. Concepts of Taxa

1. The concept of a species is generally interpreted as a recognizable and self-perpetuating population that is more or less genetically isolated.[1]

2. The concept of the genus is morphilogically logically similar species with genetic affinity to each other.[2]

3. The characteristics forming the basis of the family are generally a combination of morphilogical tendencies of related genera.[3]

4. The order ideally includes one or more families that show definite similar characteristics and evolutionary trends.[4]

II. Description and terminology of flowering plants

A. Roots

1. Primary roots are roots derived from the seed.

2. Adventitious roots are roots derived from some other part of the plant such as the stem.

3. Adventitious roots may be either from the

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[1] Ibid., p. 67.

[2] Ibid., p. 68.

[3] Ibid., p. 70.

[4] Ibid., p. 71.

lower part of a vertical stem or a modified underground stem such as a rhizome, stolon or tuber.

4. Roots of adventitious origin may also be of an aerial nature performing climbing or holding function on certain vines.

B. Stems

1. Herbaceous stems die down each year and contain very little woody tissue.
2. Modified stem structures serve specialized functions the common ones being stolons, rhizomes, tuber, corns, bulbs and tendrils.

C. Leaves

1. Leaf arrangement
   a) Alternate -- one leaf at a node.
   b) Opposite -- leaves in pairs at each node.
   c) Whorled -- three or more leaves at a single node.
2. Leaf parts
   a) Blade -- the expanded portion of the leaf.
   b) Petiole -- the leaf stalk.
   c) Stipules -- the pair of appendages at the base of the petiole.
3. Simple and compound leaves
   a) Simple -- a leaf with a single blade.

b) Compound -- blades more than one and called leaflets.

(1) Palmately compound -- leaflets arranged like fingers on a hand.

(2) Pinnately compound -- leaflets arranged on an elongated axis or rachis.

4. Leaf margins

a) Entire -- leaf margin smooth and even.

b) Serrate -- leaf margin finely cut.

c) Lobed -- leaf margin deeply cut and ends rounding.

5. Leaf venation

a) Parallel -- veins of leaf blade run parallel to margin.

b) Pinnate -- veins branch from main vein up the center of the blade.

c) Palmate -- veins branch in fan shape from base of the blade.

6. Leaf shapes: the general outline of the blade or of all the leaflets in a compound leaf omitting the petiole. For the deeply lobed leaves, the general shape is approximated around the tip of the lobes. The prefix "ob" means that the shape is inverted.

D. Inflorescences

1. An inflorescence is the arrangement of flowers on a plant.
2. The main supporting stalk of the whole inflorescence is called a peduncle, while the stalk supporting the single flower is called a pedicel.
3. Common inflorescences
   a) Dichasium -- a peduncle bearing a terminal flower and a pair of lateral flowers.
   b) Monochasium -- a peduncle bearing a terminal flower with single lateral flower below.
   c) Raceme -- an elongated inflorescence with a single pedicle bearing a single flower.
   d) Spike -- an elongated inflorescence with sessile flowers.
   e) Corymb -- a flat-topped inflorescence with a main vertical axis bearing pedicels of unequal length along it.

E. Flowers

1. The flower of most plants is made up of four main parts, namely the sepal, petal, stamens, and pistil.
2. The sepal and petal together make up the perianth and are usually obvious, with the sepal usually green and the petal colored.

3. The stamens are the male reproductive parts and consist of the anther and the filaments.
4. The pistils are the female reproductive parts and consist of the stigma, style and ovary.
5. When all four parts of the flower are present, the flower is complete. But if one or more parts are missing, the flower is incomplete.
6. There are three basic morphological flower types depending on the way the flower parts are inserted in relation to one another. These are hypogynous, perigynous and epigynous.
7. Placentation, the way in which the ovules are attached in the ovary, takes on three main patterns. These are marginal, axillary and free-central.
8. The fruit of a flower is the mature ovary.
9. A seed is a mature ovule.

III. Description and terminology of non-flowering plants

For the purpose of this description and terminology of the non-flowering plants, the plants have been grouped into the algae, the fungi, the mosses; the ferns and fern allies; and the gymnosperms. The attempt here is not to give a complete and detailed description of all the variations that occur within each of these groups. Rather, this section is intended to provide the general characteristics

and terminology applicable to the groups as a whole.

The main purpose for including such a description is to provide the reader with the basic information necessary to understand the form and organization of the major groups of non-flowering plants.

A. Algae

1. Nearly all algae live in the water.
2. Algae contain chlorophyll and are able to manufacture their own food.
3. Algae reproduce sexually to form a zygote and asexually forming motile zoospores or non-motile spores.
4. The body type ranges from unicellular non-motile to large multicellular filamentous and colonial type structure. They have no vascular tissue.
5. Most algae are microscopic and difficult to identify. The exception being the larger brown (kelp), red and some genera of green algae such as sea lettuce.
6. The green algae were probably the group from which the higher plants evolved. Each green algae cell has at least one chloroplast.

B. Fungi

1. The term fungi is commonly used to include

several groups of thallus plants that lack chlorophyll namely bacteria, slime molds, algal fungi (molds), sac fungi (yeasts, mildews, morels) and basidium fungi (rust, smuts and many of the edible mushrooms and poisonous mushrooms.)

2. Bacteria occur in three common forms: coccus, which are spherical; bacillus, which are rod-shaped; and spirillum, which are spiral. All of them are microscopic.
3. Bacteria reproduce most commonly by fission - one cell splitting into two - which under certain conditions spore formation and germination serve as a means of asexual reproduction.
4. The slime mold has a vegetative body, called plasmodium, that creeps along feeding on bits of organic matter. In time, plasmodium ceases to move and produces a number of sporangia in which the spores are produced as in other fungi. These spores upon germination produce more plasmodium.
5. The algal, sac and basidium fungi compose the true fungi.
6. The plant body of the true fungi is called the mycelium and consists of a mass of individual

filaments called hyphae.

7. Some fungi develop absorptive hyphae called rhizoids.

8. The true fungi reproduce by the formation and germination of spores that develop within the sporangia.

9. The basidium fungi have the unifying characteristics of a specialized reproductive structure called a basidium. The basidium is a club-shaped hypha on which basisiospores develop. These when germinated, form a new hyphae.

10. The fruiting body of basidium fungi consists typically of a stalk or stipe and a cap or pileus under which are gills. The gill surfaces bear the basidium which produce the basidiospores.

C. Mosses

1. Mosses grow from spores produced in capsules.

2. Each spore germinates into a filamentous thread called a protonema which eventually branches and grows into the leafy stalk of a moss plant.

3. One plant is a male plant producing the antheridium and another is the female plant

which produces the female sex organ called the archegonium. It is on the female plant that the spore producing capsule develops as a result of the formation of a zygote.

4. All mosses lack roots and true stems, and the leaves do not have veins.

D. Fern and fern allies

1. Ferns and their allies are vascular plants that reproduce by spores.
2. The ferns have true roots, stems and leaves.
3. Fern leaves or fronds from the characteristic fiddlehead.
4. The spores are produced in sporangia called sori. These are found on the underside of the frond and appear as black dots to the naked eye.
5. The spore germinates upon release from the sori into a small heart-shaped plant called a prothallus which lacks true roots, stems or leaves.
6. Upon this prothallus, both sex organs develop and a zygote is formed from which eventually a new plant with true roots, stems and leaves grows.

7. The main fern ally, of interest in this area, is the smooth horsetail which has a similar life cycle. It differs in that the spores form in a conelike structure at the tip of the hollow stalks.

E. Gymnosperms

1. They are reproduced by seeds as a result of fertilization.
2. The seeds are not enclosed in fruits as in the flowering plants but exposed as on the pine-cone scale.
3. All gymnosperms are woody plants and mostly trees. Most of the trees are evergreen.
4. The male and female gametes are formed on different cones and the fertilized egg (zygote) becomes the seed which forms on the scale of the female cone.
5. The most important and largest group of gymnosperms is the conifer.

IV. Field and herbarium methods

A. Field equipment and methods

1. A plant press is essential for preserving good specimens. A simple and inexpensive press may be constructed from white pine lattice strips, ten of which will be 12¼ inches by 3/4 inch by

1 inch, and eight strips 18 inches by 3/4 inch by 1 inch. First place two of the 12¼ inch strips 18 inches apart and parallel to each other. Then, complete the rectangle by placing two 18 inch strips on each end of the two 12¼ inch strips and glue and nail. After making sure that each corner is square, add two more 18 inch strips about 3 inches apart, glue and nail. Turn the rectangle over and nail and glue the three additional 12¼ inch strips to the 18 inch strips, spacing these about 3½ inches apart. Repeat the entire process to complete the second half of the press. This will provide two lattice grids 18 inches long by 12 inches wide.

2. The methods used to press and dry the collected plants vary. A very successful method uses corrugated cardboard pieces each 12 inches by 18 inches and newspaper to serve as blotters. First, lay one frame of the press so that the side with the long pieces is on the ground. On top of the press lay one piece of the cardboard. Follow this with about 12 or 15 thicknesses of newspaper folded to approximately the size of the press. Unfold

the upper sheet and place the specimen on the paper. Position the plant so that there is no overlapping of parts and be sure that both sides can be viewed. With the plant properly arranged, fold the paper over the plant and add 12 to 15 thicknesses of newspaper on top of it. Put another piece on top of the stack and repeat the procedure for each specimen to be pressed. When the pile of plants, newspaper and cardboards is about 12 inches high, add the second frame and begin the drying and pressing period. Place the top frame so that the long piece faces up. Pressure is applied to the frame by means of a pair of straps or ropes wrapped around the narrow portion of the frames. Place the press in the sun and allow three to five days to dry. Since Iowa weather is generally humid, it will be necessary to check the specimens daily and change the newspaper if damp to prevent blackening due to fungus growth.

3. The field notebook should be a pocket-size book that is horizontally ruled. It is used to record the number assigned to the plant as it is collected, the name of the plant if it

is known, the date of collection and other data of interest. The field number in the notebook is transferred to the plant when it is pressed and mounted.

4. The vasculum and a digger complete the essential equipment necessary for field collecting. The vasculum or container for the freshly collected plants may be either a back-pack with plastic bags for the individual plants or a standard vasculum made of sheetmetal in the form of a six inch diameter tube with a door on top. It is usually about two feet long. A digger may be a heavy sheath-knife, a geologist pick or a small shovel of some sort.

B. The herbarium

1. The herbarium is the repository of the specimens and notes of a plant collector. In the case of a small personal collection, it may consist merely of a box, or it may contain thousands of specimens as in the case of a large institution.

2. The plants are mounted on a sheet of heavy all-rag paper measuring eleven by sixteen inches. A label containing the collector's name, the field number, the scientific name

and the date of collection is placed in the lower right-hand corner of the herbarium sheet. This information is transferred from the field notebook. The dried and pressed plants are attached to the sheet by means of gummed cloth cut in strips.

C. Keys and how to use them

1. A key is a device meant to be used with the plant that is to be identified. Keys based on successive choices, known as dichotomous keys, are most commonly used and the preferred type. They should be kept as simple as possible and yet remain accurate.

2. The key that follows is of the bracket type with each pair of contrasting statements having the same indentation and the same number. The number at the end of each statement will direct the user to the next pair of statements to consider. If the statement correctly identifies the plant in question, the common name followed by the scientific name will appear at the end of the statement in place of a number. The botanical terms used in the key have been kept to a minimum. In order to keep the statements from becoming

long and cumbersome, a certain amount of terminology and nomenclature is necessary to provide adequate and accurate descriptions. Trees are not included in this key as there are several excellent keys available to identify trees.

3. The following drawings are provided to aid the user of the key in the identification of the various plant parts used in the terminology in the key. These drawings were made by a commercial artist from sketches provided by the author. Figure 1 is a longitudinal section identifying and showing the arrangement of the main parts of a regular, complete flower. Leaves may be either simple or compound. The common types of leaves are shown in Figure 2. The system of principal veins in the leaf blade constitutes its venation. Figure 3 illustrates the chief types of leaf venation. The edge of the leaf is its margin. The common types of leaf margins are shown in Figure 4. The general outline of the blade or all of the leaflets is termed its shape. Figure 5 illustrates some common leaf shapes. The shape of the tip of a leaf is often useful

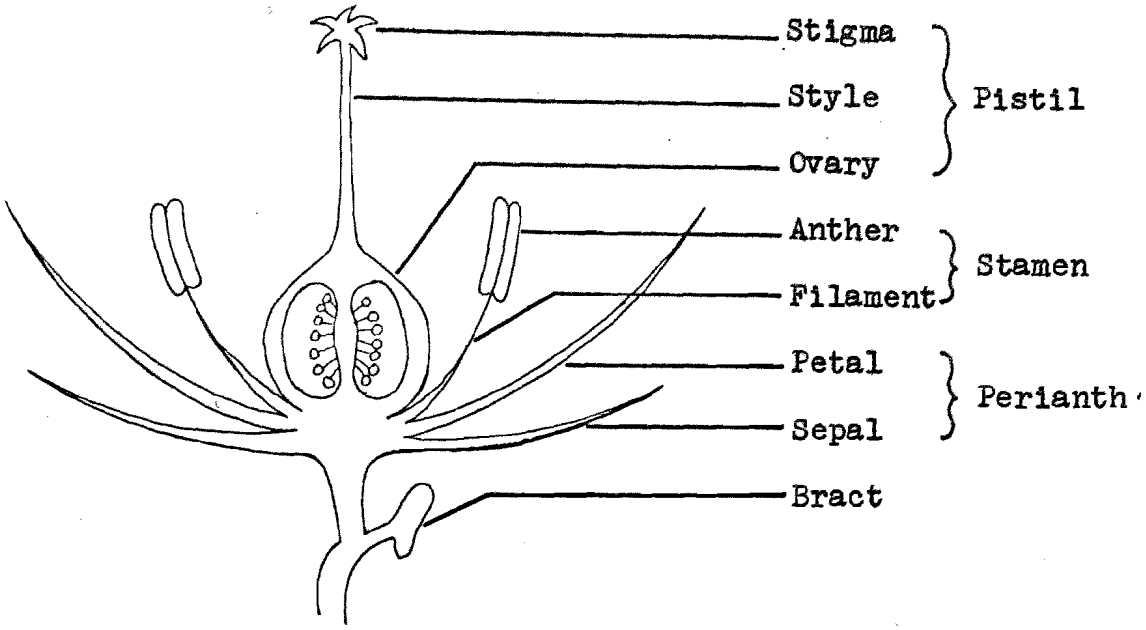

Figure 1. Longitudinal section of a regular, complete flower.

Figure 2. Types of leaves.

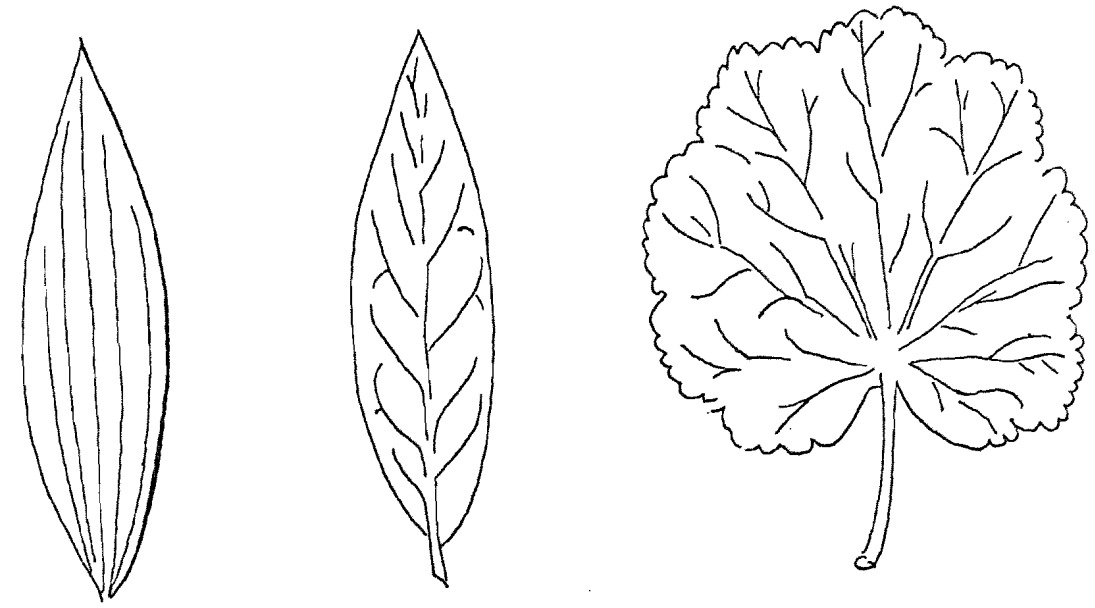

Figure 3. Chief types of leaf venation.

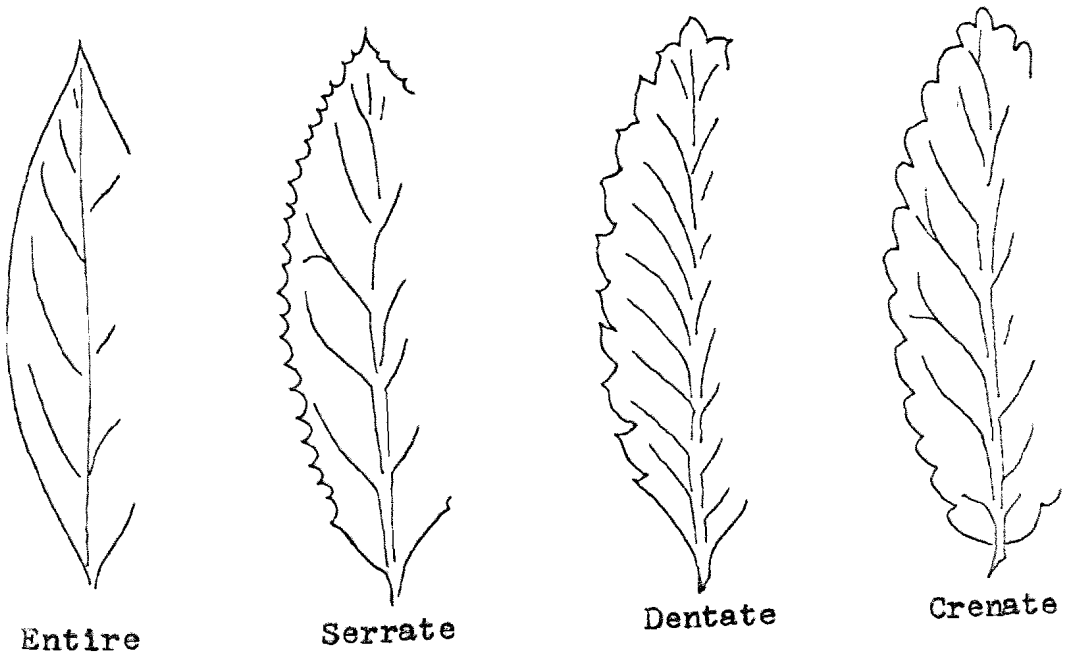

Figure 4. Common types of leaf margins.

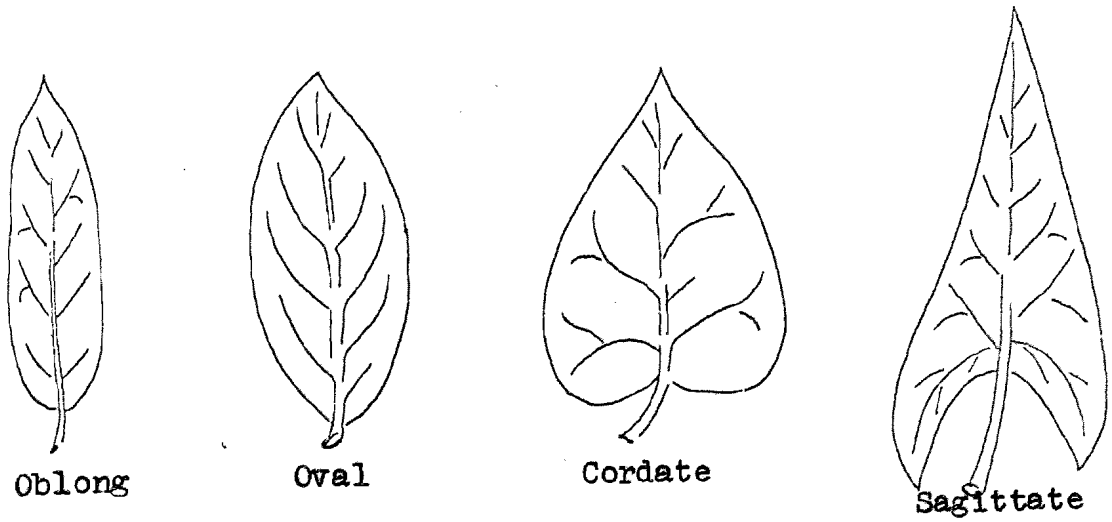

Figure 5. Some common leaf shapes.

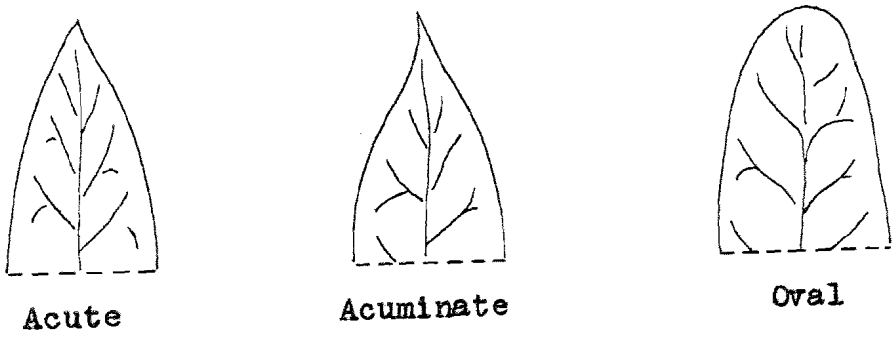

Figure 6. Leaf tips.

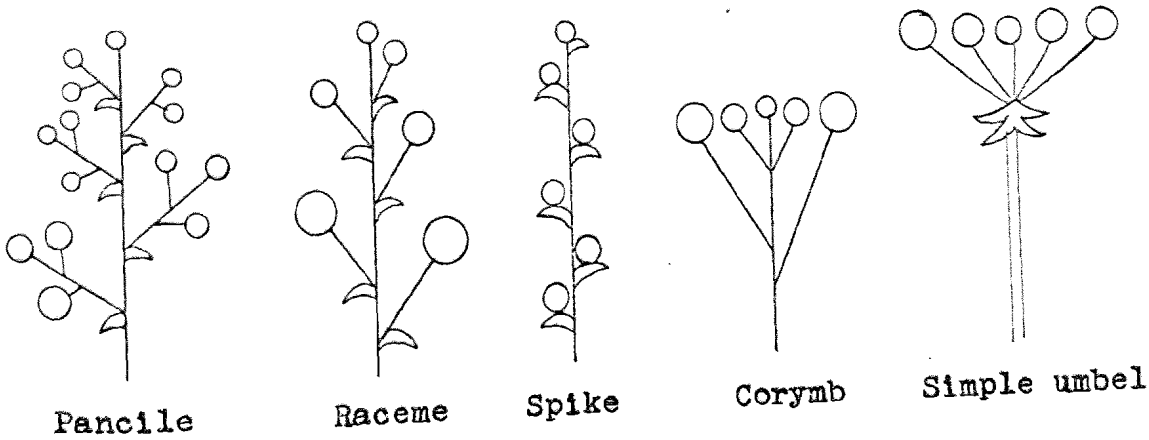

Figure 7. Common kinds of inflorescences.

in describing a particular type of leaf. In Figure 6, three common leaf tips have been shown. The arrangement of the flowers on a plant is called an inflorescence. The main kinds of inflorescences are illustrated by Figure 7.

4. This key is in no way intended to be used alone but rather in connection with an illustrated handbook such as the Golden Nature Guide, Flowers[1] or The How To Know Pictured Key Natures Series[2] by Jaques and associates. The main purpose for inclusion of the key is to acquaint the student and teacher with the use of a key and with some of the more common plants of Iowa woodlands and fields. It was in no way intended to be a complete key. It was also the intent to show the overall relationship of the plant kingdom.

D. Key to selected Iowa plants

1. Plants without distinction of root, stem and leaf; no flowers Algae or Fungi 2

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[1]Herbert S. Zim and Alexander C. Martin, Flowers, A Guide to Familiar American Wildflowers (New York: Simon and Schuster, 1950).

[2]H. E. Jaques, The How To Know Pictured Key Natures Series (Dubuque, Iowa: Wm. C. Brown Company).

1. Plants with distinct leaves or creeping green scales; without or with roots and flowers 6

2. Plants green, with chlorophyll, and appears as scum on ponds, on moist till and soil. Most forms are microscopic. Algae

2. Plants without chlorophyll (not green); living on dead or decaying organic matter or living on living organisms 3

3. Vegetative body, a plasmodium, (naked slimy flowing mass of protoplasm) usually found in loose soil or under decaying logs or leaves. Reproductive body; tiny knob or plume - like structures (sporangia) Slime molds

3. Vegetative body consisting of tiny filaments on larger stalks 4

4. Vegetative branches (mycelium) hollow and microscopic; mostly appearing as dark mold; whitish mildew or cottony masses on damp soil or water Algal Fungi (bread molds, water molds or mildew)

4. Vegetative branches (mycelium) with cross-walls and fruit on the body one-half inch or more across 5

5. Fruiting body a fleshy, spongy rounded or conical head, varying in color from tan to brown or gray; growing on a hollow stalk; the diameter is from 1 to 2 inches and a height of 2 to 4 inches Morchella sp. (most species are edible)

5. Fruiting body typically a distinct stem and cap with gills on underside; mushrooms or toadstool-like plants; cap is 2 to 6 inches in diameter and the stem from 3 to 9 inches high Gill Fungi

6. Small plants (4 to 5 inches tall) with green or gray-green leaves or leaf-like forms on damp earth or floating in water without true roots or flowers. Leaves lack veins; plants are without distinctive

stems or leaves and some are in rosettes. Mosses

6. Plants with true roots and vascular system; mostly veiny leaves 7

7. Plant without flowers or seeds, herbs propagated by spore 8

7. Plants with flowers (may be very simple) and seeds 10

8. Plants with ridged, hollow-cylindrical, jointed stems; the nodes are collared with toothlike sheaths. Spores born on terminal cone-like bodies. Height is from 2 to 4 feet. Horsetails Equisetum sp.

8. Plants with many expanded leaves and leaflets; spores are born in sporangia on backs of leaves. Young leaves arise from fiddle-like fronds. 9

9. Leaves 1 to 3 feet long, broadly triangular and divided into 3 parts, leaflets that are deeply cut. Bracken fern Pteridium aquilinum

9. Leaves 10 to 20 inches long with finely divided fan-shaped to oblong leaflets; leaf stalks shiny black; found in rich woods Adiantum pedatum Maidenhair fern

10. Plants, usually trees or shrubs, with cone-like flowers and needles or scale-like leaves; mostly evergreens Conifers (not treated in this key)

10. Plants, trees, shrubs or herbs with true flowers, seeds born in an ovary; include all our commercial flowering plants; angiosperms 11

11. Leaves usually parallel-veined, long and narrow; flowering parts in 3's; stems hollow with bundles scattered - Monocotyledons 12

11. Leaves usually net-veined; flowering parts in 4's or 5's; stems with bundles around a pithy center or woody with outer bark - Dicotyledons 27

The Monocotyledons

12. Flowers minute; surrounded by chaffy bracts (glumes); without sepals or petals; flowers grouped on spikes Grasses or Sedges 13

12. Flowers not in chaffy bracts or scales 18

13. Leaves two-ranked (in two rows on the stem); the edge of sheaths not united; stems cylindrical or flattened and usually hollow; anthers attached by their middles Grasses 14

13. Leaves three-ranked (in three rows on the stem); the edges of their sheaths united; stems triangular and solid; anthers attached at one end. Sedges

14. Flowers 2 or more to each spikelet 17

14. Flowers only one to each spikelet 15

15. Spikelets arranged in 2 rows along one side of a flattened stem 16

15. Spikelets in a solitary terminal spike resembling a slender bottle brush surrounded by yellow bristles; plant 1 to 4 feet tall with blades 6 to 8 inches long and $\frac{1}{4}$ inch wide in Giant Yellow Foxtail *Setaria glauca*

16. Leaves usually over $\frac{1}{4}$ inch wide and 2 to 6 inches long and very hairy; pedicels with sharp angles; plant 1 to 3 feet high with 3 to 6 racemes arising from the top of the stems with purplish color - Large crabgrass *Digitaria sanguinalis*

16. Leaves not over $\frac{1}{4}$ inch wide and 1 to 3 inches long; tinged with purple; pedicels cylindrical and smooth; plant $\frac{1}{2}$ to 2 feet high-Small crabgrass *Digitaria ischaemum*

17. Spikelets on panicels and drooping; 2 to 4 flowered; awns long, bent and twisted; grain has a sucker mouth at base; erect, and 1 to 4 feet high - Wild oats *Avena fatua*

17. Spikelets on raceme and erect; 5 to 8 flowered; awn not bent; erect plant 1 to 2½ feet high Common wild oat grass *Danthonia spicata*

18. Flowers with only rudimentary sepals and petals; sometimes bristles or scales 19

18. Flowers with sepals and petals; both can be quite alike 20

19. Flowers in a fleshy spike (spadix) arising from enlarged bract (spathe or hood); leaves compound; leaflets 3; spadix within the hood Jack - in - the - pulpit *Arisaema triphyllum*

19. Flowers along cyclindrical brown head (spike) with a perianth of bristles; leaves long and narrow; upper half of head staminate and light brown plant 3 to 6 feet tall; grows in marshy places - Cattail *Typha latifolia*

20. Carpels many and distinct; sepals 3 and green; petals usually 3 and white; flowers staminate or pistillate; leaves arrow-shaped grows in shallow water; 10 to 24 inches high Arrow head *Sagittaria latifolia*

20. Carpels united into one compound pistil (ovary) 21

21. Ovary hypogynous; above the calyx 22

21. Ovary epigygnous; below the calyx 25

22. Sepal green; petals white or colored; stems with long narrow leaves; flowers clustered; hairy filaments 23

22. Sepal green; petals white or colored; stems with oval leaves and a single flower on top 24

23. Perfect flowers; 3 stamens; petals unalike Day - flower *Commelina communis*

23. Perfect flowers; 6 stamens; petals all alike; sepals hairy; leaves green Spiderwort *Tradescantia virginiana*

24. Flowers perfect; perianth parts separate; Style 1; one flower on a leafless stem, nodding; rising between 2 brown spotted leaves Dog tooth violet *Erythronium albidum*

24. Flowers perfect; perianth parts separate; without a single style; one flower white to pink from axel of 3 whorled leaves; petals broad and overlapping; anthers exceed stigma; Wake robin or Trillium *Trillium grandiflorum*

25. Leaves grasslike and narrow, less than ¼ inch wide; flowers yellow; ½ to 1 inch across opening flat; flowers with tubular crown above the perianth; yellow Daffodil *Narcissus pseudonarcissus*

25. Leaves grasslike and narrow; less than ¼ inch wide; flowers blue or white 26

26. Plant short; flowers stemless; 4 to 10 inches long; early March or April Crocus *Crocus vernus*

26. Plants short; flowers ½ to 3/4 inches across on flat stems; plant 4 to 8 inches tall Blue - eyed grass *Sisyrinchium campestre*

The Dicotyledons

27. Flowers of one or more in a dense head; anthers united into a tube surrounded by an involucre 28

27. Flowers not as above; anthers not united in a tube 31

28. Flowers separate with evident calynx and corolla present 29

28. Flowers in dense head with reduced calynx of hairs or scales 30

29. Anthers touching; leaves circular; clasping stem; flowers wide open light purple to deep blue flower; grows in field and roadside; 1 to 2 feet high Venu's Looking Glass
Specularia perfoliata

29. Anthers touching; leaves very narrow and entire; plant erect, 1 to 2 feet high; flowers blue to white and bell shaped Bellflower
Campanula rotundifolia

30. Flowers born near the top of branches; erect plant, 2 to 4 feet high; leaves alternate, lanceolate and smooth; flowers yellow and grouped on branchelets, and have a pungent odor. Goldenrods
Solidago spp.

30. Flowers born on a head of one per stem; stem smooth with no leaves; leaves all from ground and toothed sharply; seeds olive green or brown Dandelion
Taraxacum officinale

31. Flowers with both sepals and petals; petals separate from each other 32

31. Flowers with both sepals and petals; petals at least partly united 38

32. Stamens more than 10 33

32. Stamens fewer than 10 35

33. Plants grow partly in water; petals oval and shiny butter - yellow color; 1½ to 2 inches across; palmately shaped leaves from base on long stems; plant 4 to 6 inches high Buttercup
Ranunculus flabellaria

33. Plant grows in rich, leafy soil; leaf is 3-lobed and single on a hairy stem; flowers bluish to white born one to a hairy stalk; flowers 1 to 1½ inches across; leaves remain through the winter Hepatica
Hepatica acutiloba

33. Plant grows in large colonies in woods; white flower born singly at the junction of large umbrella-like deeply lobed leaves; flowers 1½ to 2 inches across; plant 1 to 2 feet tall. Mayapple *Podophyllum peltatum*

33. Plants terrestrial; sepals 2; juice colored 34

34. Flowers white one on a stalk; petals long; flower stalk wrapped with single, palm shaped leaf; large tuber type root with reddish orange juice; grows in wooded area Bloodroot *Sanguinaria canadensis*

34. Flowers red, pink or white, leaves hairy; flowers born on long stems; 2 to 3 feet high perennial; flowers 4 to 5 inches across Oriental poppy *Papaver orientale*

35. Sepals 2; plant succulent with fleshy leaves and stems; leaves entire 36

35. Sepals 3 or more; plants and stems reclining; small flowers with deeply notched petals 37

36. Stamens 5; flower racemed, white with pink veins; ¼ inch across; leaves very narrow, less than ¼ inch and 4 to 6 inches long; plants 8 to 12 inches high growing in open woods or along river banks Spring beauty *Claytonia virginica*

36. Stamens 7 to 40; flowers single or clustered; ¼ inch across and yellow; many branched prostrate stems up to 1 foot long; leaves ½ to 1 inch long and oblong shaped; fleshy weed. Purslane *Portulaca oleracea*

37. Sepals separate; petals notched; styles or stigma 3; flowers white; stem and flower stalks hairy Common chickweed *Stellaria media*

37. Sepals separate; petals notched; style or stigma 5; petals white and about as long as

sepals; low (3 to 4 inches high); half creeping perennial weed; hairy Mouse ear chickweed
Cerastium vulgatum

38. Stamens more numerous than lobes of corolla 39

38. Stamens fewer than lobes or between corolla lobes 44

39. Petals very different from one another; one or two petals sac-like; stamens 6, in 2 sets of 3 40

39. Petals very different from one another; flowers sweet-pea shaped; stamens 10; all filaments united 41

40. Perennial erect herb; flowers 8 to 12 inches across with double spurred corolla above; leaves almost fernlike; common in woods Dutchman's Breeches
Dicentra cucullaria

40. Annual low herb with yellow flowers 1/2 to 3/4 inches long; spur half as long Corydalis
Corydalis aurea

41. Herbaceous plant with leaves composed of 3 leaflets; petals united into a tube; flowers in globular head 42

41. Herbaceous plant with leaves composed of 3 leaflets which are finely toothed; petals separate except for lip or keel; flowers in racemes (blue-purplish) or globular head (yellow) 43

42. Stem creeping; flowers nearly white; commonly found on lawns; plants 3 to 4 inches high Dutch or small white clover
Trifolium repens

43. Flowers in racemes 1 to 2 inches long; blue-purple; plant growing erect 2 to 3 feet high Alfalfa
Medicago sativa

43. Flowers in crowded short spikes or heads about $\frac{1}{4}$ inch across; bright yellow; stems prostrate becoming up to 1 foot long; weed found in

lawns and wasteland Black Medic
Medicago lupulina

44. Plant erect, with square stems, leaves opposite; small flower with 2 - lipped corolla or nearly equally 4 to 5 lobed; calynx nearly equal 4 to 5 parts; ovary deeply 4 - lobed; style attached between lobes; usually has characteristic mint odor 45

44. Plant a twining vine; showy trumpet shaped corolla; flowers arise singly on a stalk from the leaf nodes; stamens 5; flower open in early morning 46

45. Flowers in terminal slender spikes; leaves opposite and stalkless; plant 1 to 1½ feet high with white to pale lavender flowers; upper lip of corolla erect and flat, slightly notched Spearmint *Mentha spicata*

45. Flowers in axillary clusters; leaves opposite on short stalks; upper lip of corolla arched and entire; flowers pink to purple; about 1/3 inches long; leaves cut into 3 to 5 lobes and thin plant 2 to 5 feet high Motherwort
Leonurus cardiaca

45. Flowers on elongated terminal spikes; upper lip of corolla notched; plant erect 2 to 3 feet high; flowers whitish about ½ inch long; leaves oblong, 1 to 3 inches long, pale green and densely hairy Catnip *Nepeta cataria*

46. Style divided into two narrow stigma 47

46. Style ending in a globular stigma(s); 1 to 3 48

47. Calynx enclosed by 2 large leafy bracts at base; long running vines up to 10 feet long; leaves 2 to 5 inches long, triangular, with slender petrioles; flowers 1½ to 2 inches across and 2 inches long; pink with white stripes or all white Wild morning glory
Convolvulus sepium

47. Calynx without bracts at base; trailing stems 1 to 3 feet long; leaves 1 to 2 inches long

and triangular; flower white, weed in fields and lawns Creeping Jenny or field buckweed
Convolvulus arvensis

48. Flowers 2 to 3 inches long; blue to pink or white; leaves entire and heart-shaped, 2 to 4 inches wide; dark green; hairy twining stems up to 10 feet long; sometimes cultivated Morning Glory
Ipomoea purpurea

Glossary[1]

Axillary - from a point where a leaf joins the stem.

Bract - a small scale-like leaf.

Compound - a leaf divided into separate parts or leaflets.

Corolla - petals collectively.

Calynx - sepals collectively.

Disc flowers - the tubular flowers on head of Compositae.

Glabular - knobbed shape.

Inflorescence - the entire group of flowers.

Involucre - a circle of scales or leaves around inflorescence.

Lip - the upper or lower part of a 2-sided flower.

Node - the point of a stem where leaf or branches attach.

Perfect - having both stamens and pistils in same flower.

Perianth - the covering of a flower, the sepals and petals.

Regular - all sepals, petals and stamens like one another.

Spadix - a fleshy axis, bearing flowers.

Spike - a main stalk with flowers directly on it.

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[1]Henry S. Conard, *Plants of Iowa* (Grinnell: The Author, 1951), pp. 85-86.

Spore - a microscopic one-celled propagating body.

Spur - a tubular projection from a flower, usually a part of the corolla.

Whorl - with 3 or more leaves in a circle at one node.

2, 3, 3-ranked - in 2, 3, 4, etc. vertical rows on the stem.

Principles. From the coverage of the materials in the outline, certain principles are expected to be developed. They are as follows:

1. A plant is positively identified by its scientific name, which consists of its generic name and the specific epithet.
2. Plants are arranged in groups which show their true genetic and evolutionary relationships. These groups are called taxous, which are established by the type method.
3. A plant has only one valid name. It is established on the principle of priority.
4. Roots are not all originated from the seed but some from plant parts.
5. In herbaceous plants, the stems die down each year.
6. Leaves vary in size, shape, venation and arrangement on the stems.
7. The inflorescence of a plant is the way in which the flowers are arranged on the plant and is useful in identification of some plants.

8. The main function of a flower is reproduction. The flower of most plants consists of sepals, petals, stamens and pistils. The stamens and pistils may or may not be within or on the same flower or plant.
9. The ripened ovary of a flower is called the fruit.
10. Most algae live in the water and reproduce sexually and asexually.
11. Fungi consist of a group of plants that lack chlorophyll.
12. Fungi lack a true vascular system.
13. Fungi reproduce by the germination of spores.
14. All mosses lack roots, true stems and veined leaves and reproduce by spores.
15. Ferns have a vascular system but reproduce by germinating spores.
16. The gymnosperms reproduce sexually by formation of zygotes which form a seed not enclosed in an ovary.
17. All gymnosperms are woody plants and mostly evergreen trees.
18. Successful preservation of plant specimens depends upon careful and complete drying and pressing of each plant.
19. The herbarium is a repository of plant specimens.

20. The herbarium sheet contains the scientific name of the specimen as well as the collector's name, date and place of collection.
21. The use of a dichotomous key is dependent upon the selection of one of two or three choices that best describes the plant in question.

II. SUGGESTED ACTIVITIES

The following activities are suggested to aid the students in a better understanding of plant taxonomy.

Reports. Oral and written reports can be used to give the students the opportunity to delve into a certain phase of the subject more thoroughly. The students also can benefit from each others report on such topics as:

1. Medicinal plants (plants and uses of each)
2. Edible wild plants (parts of plant which is edible)
3. Laws to protect wild flowers
4. Soil and light requirements of wild plants
5. Techniques for photographing wild flowers
6. Rare plants of your area (where located and how many kinds)
7. How to make a terraria for growing small non-flowering plants
8. Methods of growing algae cultures
9. How to make spore prints

10. The evolutionary development of the seed bearing plants (the flowering plant)
11. The dual organisms called lichens
12. The life cycle of wheat rust
13. The "Fairy rings" produced by mushrooms (what is the cause of them)
14. Plants that grow under extreme weather conditions (in very cold or very dry areas)
15. How new plant varieties can be produced (crossing hybridization)
16. Insect pests (both wild flowers and cultivated flower pests)
17. Various methods of pollenization in flowering plants
18. Darwin (Origin of Species)
19. Carolus Linnaeus (binomial system of nomenclature)
20. Asa Gray (Gray's Manual of Botany)

Plant collections. Collections make possible the study of plants in more detail than can be done in the field. The value of a collection can be greatly increased when accompanied by a good set of field notes. It is well to practice pressing and mounting a few common weeds until they can be mounted without spoiling them, before starting a permanent collection.

The following are some suggested types of collection that are possible:

1. Plants of different habitats such as woodland, open fields, swamps or ponds
2. Medicinal plants
3. Plant families (a number of plants of one family)
4. Seasonal flowers such as spring, summer or fall blooming plants
5. Flowers all of one color
6. Edible plants

Field study. The observing of plant life in their natural surroundings affords the students an opportunity to see the plants in relationship to the other elements of their environment. The field method is perhaps the best means of learning to identify plants.

It is after several of these field trips that the student will begin his plant collection. A field guide and a check list of common Iowa flowers and trees would be most helpful in the field study. Perhaps the students would want to keep a list of the plants identified and their location. A pocket size special notebook would be most useful for this part of the field study.

The following is a brief check list of the approximate flowering dates of some of the common Iowa woodland flowers. This list was adapted from the June, 1967, issue of the Iowa Conservationist.

Early Spring - April

1. Trillium (Dwarf)
2. Hepatica
3. Bloodroot
4. Shad bush

Around May 1

1. Rue Anemone
2. Dog-tooth Violet
3. Violets
4. Prairie Wakerobin
5. Dutchman's Breeches
6. Bluebells

Late Spring May 10 to 15

1. Spring Beauty
2. Wood Anemone
3. Wild Crab
4. Wild Plum
5. Wild Cherry
6. Jack - in - the - pulpit
7. Sweet William or Woodland Phlox
8. May Apple
9. Solomon Seal
10. Wild Geranium
11. Wild Ginger
12. Buttercups

13. Columbine
14. Bellwort
15. Wild Rose - around May 30

Mid-Summer - July

1. Black-eyed Susan
2. Turks Cap Lily

Late Summer - August

1. Jewel Weed
2. Great Lobelia
3. Indian Pipe and Broom Rape
4. Boneset

Plant photography. Most flowers can be easily photographed with a camera and a portrait lens attachment. In addition to the portrait lens, which makes possible close-ups, a cable release tripod and a light meter will improve the quality of the pictures. Color film is recommended for the most rewarding results.

It has been the experience of the author that it is best to photograph the plants in their natural surroundings with natural day light. It is difficult to get the proper lighting with artificial flood lights. Cloudy and windy days should be avoided for best results.

To assure properly exposed and focused pictures, it is advisable to take two or three pictures with slightly different settings. A small pocket notebook, in which the

number of the picture, the name of the plant and the settings for each picture is recorded, can prove helpful in learning which settings give the best results. Also the sky conditions and wind, if any, could be noted for each picture.

Wild flower gardens. A wild flower garden can prove to be a rewarding project as well as good learning experience for the student.

The first step in establishing such a garden is, from the observations of field trips, determining the type of soil and light conditions which the plants have to have to grow. Unless their conditions are kept very much the same, the transplants or seedlings will not survive. When digging the plant for transplanting, take some of the soil with it and be sure to include enough of the plant so as to not injure the root system. Generally, a shady area with a rich organic soil is the best for most woodland plants.

If the plants are to be started from germinating wild seeds of perennials, the seeds should be planted in the fall and allowed to lay in the ground over winter. They will then germinate in the spring and grow into young seedling plants. Once the wild flower garden is established, a student may want to attempt plant breeding and crossing.

Construction of keys. A key is a device for identifying unknown objects. Keys based on successive choices between only two statements are known as dichatomous keys. In using and constructing keys, occasionally it is necessary to have three or even four choices to arrive at the proper answer.

In constructing a key, a few guide lines are set forth below:

1. Use constant characteristics.
2. Select characteristics that divide the material into two clear cut parts.
3. If possible, start all choices of a group with the same word.
4. Use measurements in terms of inches rather than "small or large."
5. Begin each statement with the name of the part to which the description terms apply.
6. Keep the key simple, arriving at the correct answer in as few choices as possible.

The students can learn a great deal about the using of a key if they have the opportunity to construct a simple key. Perhaps they can start out by constructing a key to separate and identify various kinds of wood screws. The instructor could give the student ten different kinds of screws and have the student construct a key to classify and

identify the screws found in the group.

When the students have mastered the mechanics of a key, they can then be given a group of plants and be asked to construct a key that would identify each of the plants found within the group. A comparison chart listing the characteristics to be compared such as the shape of leaves, type of flower, number of petals, etc., and the plants to be keyed should preceed the key itself. This helps avoid using characteristics in one statement and not in the corresponding one.

The final check on the reliability of a key, is to check the description of the plant so keyed to see if it agrees with a known speciman of the same plant.

III. EVALUATION

The main consideration in any evaluation program is to determine whether the objectives of the unit were achieved. It should attempt to determine the strength and weakness of the students in relationship to the objectives.[1] The evaluation program should be used throughout the unit and be an integral part from the beginning to the end each

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[1] Elwood D. Heiss, Ellsworth S. Obourn, and Charles W. Hoffman, Modern Science Teaching (New York: The MacMillian Co., 1950).

time with a different purpose in mind.[1]

The evaluation program, in an attempt to give a complete appraisal of the student's growth, has several obligations.

> . . . first to devise tests and measures that will reveal not only the mastery of facts and principles of a given area, but also a functional understanding of the concepts and generalizations involved; and second, to devise techniques for revealing growth in certain other outcomes such as reflective thinking, attitudes, creativeness, personal interest and social sensitivity.[2]

The two above suggestions provide the basis on which the evaluation can be instituted. The specific approach to each of these is outlined below:

I. Evaluating Growth in Functional Understanding

A. Purely Verbal Tests

1. Essay questions. It is the aim of this type of measurement to judge the more intangible aspects such as attitude, interest, orderly thinking, and the grasp of the fundamentals.

2. Objective Tests

a) Completion. These tests measure how well a student can recall important factual information.

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[1]Walter A. Thurber and Alfred T. Collette, Teaching Science in Today's Secondary Schools (second edition; Boston: Allyn and Bacon, Inc., 1964), p. 277.

[2]Heiss, Obourn, and Hoffman, op. cit., p. 18.

b) Multiple Choice. It, unlike completion, stresses recognition, but can also measure the pupil's ability to weigh and relate facts.

c) Matching tests. Here a student reveals his ability to follow directions and to associate related facts.

d) True-False items. If carefully written, it is a test that can reveal the student's factual knowledge as well as the student's reasoning ability. The test can be modified to include some items that would require the false statement to be corrected. This would give more of an indication as to the depth of the student's knowledge.

e) Arrangement test. This type of test is useful evaluating the student's knowledge of sequence and order.

B. Non-Verbal Tests (Using Methods)

1. Performance test. This test can measure understandings and abilities that are difficult to verbalize. It measures the pupil's ability to carry out certain operations. For example, the student could be given a plant

told to properly mount it on a herbarium sheet.

2. Identification test. This type of test is ideal for a unit on plant taxonomy. As with performance tests, the pupils are working with actual materials and require little verbalization. The test measures their true understanding of procedures. The student, for example, can be given five plants and instructed to key them out to determine their names.

3. Recognition test. In this type of test, familiar plants are presented to the student and he is to properly name each one. This type of test measures the pupil's ability to recognize and name actual plants and plant parts. It is superior to a purely verbal test for the same purpose. With some modification, this test can be used to test knowledge of characteristics and uses more than identification of the speciman. An example of this would be to give the pupil a certain plant and ask for a certain identifying characteristics of the family to which this plant belongs and the major use of the plant.

4. Diagram and model test. A model or diagram of a plant part would be displayed. The student would be asked to identify the part and, briefly, explain its function. This would be particularly helpful for internal structures which are small and difficult to see on the living material.

II. The Evaluation of Scientific Attitudes and Interests

A. Anecdotal records. The main purpose of this is to show the student's day to day development. Class recitation, willingness to do extra projects over and above the minimum requirements and overall inquiring attitude can be included. Recording incidents pertaining to these areas will help indicate any change and growth of the student's attitudes and interests.

B. Written and oral reports. These devices will indicate the pupil's abilities to search for pertinent information pertaining to the area of study and the condensing of it into a meaningful report. These reports will also give some measure of the student's organizational abilities and the depth of his scientific interest.

C. Plant collection. The plant collection should reveal the student's attitudes, interest and crea-

tiveness. These can be judged by the neatness and accuracy of the mounting and identification of the plant. The number of the plant families collected and the arrangement of these in the collection would indicate a great deal about the interest and creativeness of the student.

D. Special projects (wild flower gardens, plant photography, special collections, etc.) These measure the student's initiative, willingness and capability to work independently.

It will be noticed that all of the above tests and evaluation methods provide not only a means to help the teacher evaluate the student's achievement but also provide learning situations for the student. These tests also give some clue as to the effectiveness of the procedures used by the teacher during the unit.

In summary, the following considerations are to be taken into account as a part of the evaluation program.

1. The need for evaluating learning outcomes of many types.
2. The use of a variety of evaluation techniques.
3. The individualization of evaluation as a basis for grading.
4. The diminishing of emotional tension in evaluation.[1]

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[1] Edward A. Krug, Curriculum Planning (New York: Harper and Brothers, 1950), p. 267.

IV. SUGGESTED MATERIALS

The following list of suggested materials will make the study of plant taxonomy more meaningful and interesting to the students and thereby aid their learning.

Films. Most of the films can be obtained on a rental basis from film libraries or free from private concerns. All the films listed are 16 mm. They are all recommended for the junior and senior high school grade level.

The following films may be obtained free, except for the postage from the private concern listed following the description.

The Cell (Sound, 15 minutes). This film describes and shows parts of a cell using a cell model.

Sterling Movies, U.S.A.
43 West 61st Street
New York, New York 10023

Flowers a Wonderland (Sound, 13 minutes). This film tells the story of the flower show of New York.

International Flower Show
Dept. of Creativison
1780 Broadway
New York, 19 New York

How to Collect and Preserve Plants (Sound, 13 minutes). This film shows in full color the steps and equipment needed to collect, classify and mount specimens.

Illinois Natural History Survey
Mr. James Ayara, Tech. Ed.
189 Natural Resource Bldg.
Urbana, Illinois

Linnaeus (Sound, 18 minutes). This film tells the life story of Linnaeus the Swedish botanist.

Swedish Film Center
Dept. of Creativision, Inc.
1780 Broadway
New York, New York 10019

Riddle of Photosynthesis (Sound, 12½ minutes). This film illustrates the research on plants systhesis using radioactive carbon as a tracer.

U. S. Atomic Energy Commission
Div. of Public Information
Office of Information
9800 S. Cass Avenue
Argonne, Illinois 60439

Time-lapse Flower Magic from Hawaii (Sound, 11 minutes). This film in full color shows the range of flowers and how they grow by use of time-lapse photography.

Hayes Spray Gun Co.
Film Division
98 N. San Gabriel Blvd.
Pasadena, California

The following films may be either purchased or obtained on the rental basis from:

McGraw-Hill Book Co.
Text-Film Div.
327 West 41st Street
New York, New York 10036

These films are the AIBS Film Series and are available in either black and white or color. Student Study Guides are available with each film for $1.00 each.

What is a Cell (Sound, B&W or color). This film dis-

cusses the various cell parts and their function.

Leaves (Sound, B&W or color). The structural features of the leaves are discussed and their role in metabolism.

Roots (Sound, B&W or color). The role of roots in the absorption of water and food and in the anchorage of the plant is shown or discussed.

Stems (Sound, B&W or color). A discussion and illustration of the structure of stems and their main functions in the plant is shown in this film.

Flower Structure (Sound, B&W or color). The structures of the flower are shown and the film describes their role in seed production. It traces the reproduction cycle from fertilization to maturity.

The Algae (Sound, B&W or color). This film illustrates the classification of algae into phyla or divisions and describes its life cycle.

The Lower Fungi (Sound, B&W or color). The classification of the phycomycetes is described along with the methods of collecting them.

The Higher Fungi (Sound, B&W or color). This film describes and illustrates the basidiomyctes and ascomycetes along with the typical life cycle of these plants.

The Bryophytes (Sound, B&W or color). This film illustrates the life cycle of the mosses and liverworts.

Fern and their Allies (Sound, B&W or color). A description of the alternation of generations is given in this film along with the fossil history of the ferns.

Life of Angiosperms (Sound, B&W or color). The development of the flowering plants and the differences between the monocotes and dicots are described.

The following films may be obtained on the rental basis from:

Encyclopedia Britannica Educational Corp.
District Office
Mr. Dale Cooley
2901 Boston Street
Des Moines, Iowa

Angiosperms - The Flowering Plants (Sound, 21 minutes, color, #1932). The structure and reproduction of the flowering plants are described and their importance to man is explained.

Flower at Work (Sound, color, 11 minutes, # 1433). This film explores the process of cross-pollination, self-pollination and fertilization.

How Pine Trees Reproduce (Sound, color, 11 minutes, # 2142). This film uses time lapse photography to explain the processes involved in reproduction in pines.

Seed Germination (Sound, color, 15 minutes, # 1837). This film explains how seeds serve plants in reproduction and how seed germination takes place.

Origin of the Land Plants (Sound, color, 15 minutes,

#2017). This film traces the evolution of the land plants and illustrates characteristics, reproductive processes and adaptive mechanisms of the mosses and liverworts.

These films are available on a rental basis from the film library at Iowa State University:

Visual Instruction Service - 1967/69 catalog
Iowa State University
Ames, Iowa 50010

Angiosperms-The Flowering Plant (Sound, color, 20 minutes, NS-6031). Examples of different flowers and the parts of the flowers are shown. The reproduction function is also shown.

Evolution of Vascular Plants-The Ferns (Sound, color, 20 minutes, NS-1605). This film describes the evolution of vascular land plants and how they adapted using the fern as an example.

Flowers at Work (Sound, B&W, 10 minutes, NS-504). This film begins with time lapse photography of the lily, shows parts of flowers in cut-away and also the cycle from fertilization to seed production in animation.

Fungi (Sound, color, 15 minutes, NS-4175). This film shows the fungi as simple plants that lack chlorophyll and are saprophytes.

Growth of Plants (Sound, color, 16 minutes, NS-1453). This film compares the growth of plants to animals, plant parts and functions.

Gymnosperms (Sound, color, 17 minutes, NS-1463). This film traces the life of the pine cone to maturity. It contains time-lapse photography.

Learning About Leaves (Sound, B&W, 16 minutes, NS-3272). This film compares different kinds of leaves and shows how leaves are related to other parts of the plant and the function of leaves.

Life of a Plant (Sound, color, 11 minutes, NS-3661). This film shows steps in the life cycle of a typical flowering plant. It identifies the roles of roots, stems, leaves, fruit and seed.

Life Story of a Fern (Sound, B&W, 17 minutes, NS-3246). This film studies three generations in the life history of the fern, the structures of the male and female organs and process of fertilization.

Plant Motions, Roots, Leaves and Stems (Sound, B&W, 11 minutes, NS-4231). This film shows movements of leaves, stems, and roots. It shows the response of roots, stems and leaves to light and gravity.

Photosynthesis (Sound, color, 21 minutes, NS-1662). This film explains how green plants transform light energy into food.

Roots of Plants (Sound, B&W, 11 minutes, NS-610). This film describes the different types of roots and explains their functions.

Secrets of Plant World (Disney color, sound, 15 minutes, NS-4270). This film uses stop action motion cameras to show natures' secret processes and devices which help plants to survive, e.g. burrowing in the ground.

Simple Plants: Algae and Fungi (Sound, B&W, 14 minutes, NS-605). This film describes the major characteristics of simple plants and shows how they differ from higher plants.

The following films can be rented from the film library at the University of Iowa:

Audiovisual Center (1966/69 catalog)
Div. of Extension and University Service
University of Iowa
Iowa City, Iowa 52240

Aristotle and the Scientific Method (Sound, B&W, 14 minutes, U-5241). This film summarizes Aristotle's contribution to science and the scientific method.

Growth of Flowers (Sound, color, 11 minutes, U-2191). This film uses time-lapse photography to show the activity of plants during their growth period.

Plants That Grow From Leaves, Stems and Roots (Sound, color, 11 minutes, U-5448). This film shows how plants can be propagated from leaves, stem cuttings and root cuttings by vegetative reproduction.

Trees - How We Identify Them (Sound, B&W, 11 minutes, U-4889). This film shows how to identify trees by shape, leaves and fruit. It also illustrated the difference

between hard and soft woods.

What is Science? (Sound, B&W, 11 minutes, U-2369). This film defines science, its components of study and the use of the scientific method.

8mm film loop. These film loops can be purchased from:

Ealing Film Loops
2225 Mass. Ave.
Cambridge, Mass.

Flowers and Trees - Buds to Blossoms (Color, 4 minutes, 81-329). This time-lapse photo is of a bud opening and closing.

Seed Dispersal (Color, 2 minutes, 81-963). This loop shows pods bursting and releasing their seeds.

Self-Planting Seeds (Color, 3½ minutes, 81-965). This loop shows how seeds move and imbed themselves in the ground.

Seeds Sprouting (Color, 3 minutes, 81-965). This loop shows the germinating of seed and the sprouting of roots by time-lapse.

Climbing Vines (Color, 2 minutes, 81-966). This one shows the growth of vines and how the tendrils whip about and attach for support.

Fruit Ripening (Color, 1½ minutes, 81-967). By time-lapse, this loop shows the growing ripening of fruit.

Flower Opening (Color, 3 minutes, 81-968). This loop

shows the vigor with which flowers unfold and expose their stamens and pistils.

Mushrooms (Color, 1 minute, 81-968). In this loop, mushrooms are seen pushing up out of the ground and growing to full-size plants. Gills on the underside are shown.

Preserved materials. The following set of preserved materials will aid the student in gaining a better understanding of the plant kingdom. These specimens are mounted on backing in wide-mouth jars with metal caps.

Basic Botany Set. This includes Nostoc, Spiragyr, Fucus, mushrooms, Marchantia, fronds of ferns, male and female cones and Lily flower plus key cards.

Plant Reproduction Collection. This set includes seed, storage root, bulb, runner, stem cutting, underground stem and leaf.

Monocot and Dicot Comparison Set. This set includes one each of a monocot and a dicot stem, leaf, flower, fruit and seedling.

Leaf Type Set. This set includes twelve leaf types in a wide-mouth jar.

Flower Types. This set includes five flowers; one each of hypogynous, perigynous, epigynous, separate carpels and a composite. Each flower is in longitudinal section in a museum jar.

The above mentioned materials can be purchased from:

Turtox Biological Supply
8200 S. Hayne Avenue
Chicago, Illinois 60620

Charts. The following charts, with identifying numbers, will aid the teacher in imparting a better understanding of the life cycles and features of the various groups of plants.

CR5004 Plant Kingdom and Phylogenetic Tree. This shows the relationship of the entire plant kingdom.

T105 Algae. This is a full color wall chart showing the vegetative and reproductive stages of typical algae.

T130 Lily. This one illustrates flowering plants, cross-sections of the anther and entire ovary in full color.

T116 Moss. This illustrates the growth habits and life cycles of mosses in full color.

T110 Mushrooms. This chart illustrates the growth habits and life cycle of the mushrooms.

The above mentioned charts are also available from Trutox Biological Supply.

Overhead transparencies. The following color transparencies may be used to bring out relationships and emphasize essential ideas related to the study of plant taxonomy:

TBB-102 The Woody Stem--three overlays

TBB-103 Structure and Function of a Leaf--two overlays

TBF-101 Parts of a Flower--two overlays

TBF-103 Fertilization of the Flower--two overlays

TBS-201 Structure of the Plant Cell--four disclosure masks

TBF-104 The Flowering Plant

The preceeding transparencies along with a teacher's guide can be purchased from Turtox Biological Supply House.

Microscopic slides. The following slides will show the detail structure of selected algae and certain other plant structures. These understandings are necessary for full comprehension of plant classification.

1B12 Gleocapsa. Unicellular alga, blue-green.

1B211 Euglena. Green alga stained, w.m.

1B256 Spirogyra. Green alga, vegetative filament.

7B109 Roots. Monocot and Dicot roots on same slides.

7B311 Stems. Monocot and Dicot stemson same slides.

7B509 Leaves. Monocot and Dicot leaves on same slides, x.s.

8B110 Flowers. Monocot and Dicot flowers on same slide, x.s.

8B260 Lilium. Shows l. s. of pistil, stigma, style and ovary on same slide.

The microscopic slides can be purchased from Trutox.

Lantern slides. These 3 x 2 slides can be used to supplement the living materials to illustrate the major type of flowers found in this area.

Flower Type Set. A set of fifty slides showing the major types of angiosperms. This set is available from Trutox Supply.

General Botany Set. A set of fifty slides covering the major plant families studied in an introductory botany course. These slides are also available from Trutox Supply.

Iowa Spring Wild Flowers. A set of forty colored slides and notes showing the common Iowa spring wild flowers is available from the I.S.U. Visual Instruction Service, Iowa State University, Ames, Iowa.

V. REFERENCE MATERIALS

The following materials will be of aid to the student in his study of plant taxonomy.

Books for students. The following reference books were selected on the basis that they can be read and understood wholly or in part by most junior high school students.

Aikman, J. M., Key to Native Trees and Shrubs of the Mitigwa Scout Reservation. Des Moines: Tall Corn Area Council, B.S.A., 1964.

Conard, Henry S., How To Know The Mosses and Liverworts. Dubuque: Wm. C. Brown Co., 1956.

Cuthbert, Mabel J., How To Know The Fall Flowers. Dubuque: Wm. C. Brown Co., 1948.

Cuthbert, Mabel J., How To Know The Spring Flowers. Dubuque: Wm. C. Brown Co., 1948.

Jaques, H. E., How To Know The Trees. Dubuque: Wm. C. Brown Co., 1948.

Jaques, H. E., Plant Families - How To Know Them. Dubuque: Wm. C. Brown Co., 1949.

Jaques, H. E., How to Know The Weeds. Dubuque: Wm. C. Brown Co., 1959.

Love, Robert F., Botany. New Bruinswick: Boy Scouts of America, 1964.

Pohl, A., How To Know The Grasses. Dubuque: Wm. C. Brown Co., 1953.

Slife, F. W. (ed.), Weeds of the North Central States. Urbana: University of Illinois, 1960.

Sylvester, E. P., Noxious Weeds of Iowa. Des Moines: State of Iowa, 1965.

Zim, Herbert S. and Floyd Shuttleworth, Non-Flowering Plants. New York: Golden Press, 1967.

Zim, Herbert S. and Alexander C. Martin, Flowers, A Guide to Familiar American Wildflowers. New York: Simon and Schuster, 1950.

Zim, Herbert S. and Alexander C. Martin, Trees, A Guide to Familiar American Trees. New York: Simon and Schuster, 1956.

Books for teachers. Besides the books listed here for the students, the following can also be used by the teacher.

Bold, Harold, Morphology of Plants. New York: Harper and Row, 1957.

Bold, Harold, The Plant Kingdom. Englewood Cliffs: Prentice-Hall, 1964.

Cobb, Boughton, A Field Guide to the Ferns. Boston: Houghton Mifflin, 1956.

Conard, Henry S., Plants of Iowa. Grinnell: The Author, 1961.

Felnald, M. L., Gray's Manual of Botany. 8th ed., New York: American Book Co., 1950.

Gleason, H. A., New Brittain and Brown Illustrated Flora of the Northeastern States and Adjacent Canada. New York: 1952.

Hylander, Clarence J., The World of Plant Life. New York: The MacMillan Co.

Maldenke, Harold N., American Wildflowers. New York: Van Nostrand Co.

Porter, C. L., Taxonomy of Flowering Plants. San Francisco: W. H. Freeman and Co., 1959.

Prescott, Gerald W., How to Know Fresh-Water Algae. Dubuque: Wm. C. Brown, Co.

Russell, Norman H., Introduction to the Plant Kingdom. St. Louis: C. V. Mosley Co., 1958.

Smith, Alexander H., The Mushroom Hunter's Field Guide. Ann Arbor: The University of Michigan Press, 1963.

Tippo, Oswald and Harry J. Fuller. College Botany. New York: Henry and Holt Co., 1949.

Wherry, Edgar T., The Fern Guide. Garden City: Doubleday and Co., 1961.

Weson and Loomis, Botany. New York: Holt, Rinehart and Winston, 1962.

Periodicals. The following periodicals are dependable sources of information regarding the constant new developments in the field of taxonomy:

The American Biology Teacher

Iowa Conservationist

The Instructor

National Geographic Magazine

Science

The Science Teacher

The following are sources of information regarding recent developments in the field of plant taxonomy and related areas. These articles will be of interest primarily to the teacher, with the exceptions of the ones in the National Geographic, which would be of interest to the student as well:

Finsley, Charles, "Key to Identification," The Instructor, XXVI, October, 1966, pp. 110-111.

Hamon, A. C., "Understanding a Key," The Science Teacher, XXXI, March, 1964, p. 63.

Iowa Conservationist Staff, "Iowa Wildflowers," Iowa Conservationist, Vol. 26, June 1967, pp. 44-45.

Russell, Norman, "Teaching Modern Taxonomy," The American Biology Teacher, 27, December, 1965, pp. 789-791.

Zahl, Paul, "Malaysia Giant Flowers and Insect Trapping Plant," National Geographic, Vol. 125, No. 5, May, 1964, pp. 680-700.

Zahl, Paul, "Plants That Eat Insects," National Geographic, Vol. 119, No. 5, May, 1961, pp. 643-660.

Zahl, Paul, "Bizarre World of the Fungi," National Geographic, Vol. 128, No. 4, October, 1965, pp. 502-527.

Pamphlets. The following pamphlets will serve as additional sources of information to supplement that which is available in regular books.

Iowa State Conservation Commission. Simple Key to Iowa Trees. Des Moines: Iowa State Conservation Commission.

Iowa State Conservation Commission. Check List of Common Iowa Woodland Flowers. Des Moines: Iowa State Conservation Commission.

Iowa State University, Extension Service. Keys for Trees of Iowa. F-282 (rev). Ames: Iowa State University Extension Service, 1965.

Iowa State University, Extension Service. Trees of Iowa. Extension Bulletin P 121 (rev). Ames: Iowa State University Extension Service, 1961.

Pohl, Richard and Paul Morison. Keys to Families of Vascular Plants of Iowa. Ames: Iowa State University Press.

Free materials. The following free materials will aid the teacher where budget is limited.

Educational Focus.

Published by Bausch and Lamb Optical Company, Rochester, New York. It covers current developments and studies in areas where microscopes are used.

Turtox News.

Published by General Biological Supply House, Inc., 8200 South Hayne Avenue, Chicago, Illinois 60620. An excellent bulletin that is published monthly with articles on all phases of biological science.

Turtox Service Leaflets.

These service leaflets comprise a series of sixty informational pamphlets which have been prepared for use by biology teachers in the secondary schools. One complete set will be mailed gratis upon request to any secondary school biology teacher. The leaf-

lets are supplied to students, or in quantities at the actual cost of publication and mailing -- five cents per leaflet or $4.00 per hundred copies; assorted as desired. For plant taxonomy; Number 6, Growing Fresh-Water Algae; Number 25, Non-Flowering Plants and Number 60, Plant Culture with Artificial Light.

Welch Biology and General Science Digest.

Published by the Welch Scientific Company, 7300 N. Linder Avenue, Skokie, Illinois 60078. This pamphlet contains articles in digested form from many scientific magazines. It gives ideas for science projects and instructeous laboratory techniques.

CHAPTER III

SUMMARY

The purpose of this study was to prepare a resource unit on plant taxonomy for the use of junior high school science teachers. The field of plant taxonomy is one area in which there has been a lack of material available to science teachers at junior high level.

One of the major aims of this resource unit was to provide the teachers with adequate information and sources of various materials from which a unit of study suitable to the local classroom could be developed. The literature on curriculum and planning was surveyed to provide the approach and pattern of organization for the resource unit.

In the gathering and organization of the materials and information dealing with plant taxonomy, various junior and senior high school science texts and curriculum guides were first surveyed. It was found that there was a general inadequacy in the coverage of this area. It was therefore necessary to use college textbooks in introductory plant taxonomy, introductory botany books and various field guides to secure acceptable coverage of plant taxonomy. Various keys and field guides were useful in the selection of activities and materials for the unit.

The unit is organized as follows:

1. The area of plant taxonomy. This includes an introductory discussion of plant taxonomy, followed by a detailed outline covering nomenclature, plant description and terminology, field and herbarium methods and a key. This section of the unit is concluded with the statement of twenty-one general principles which can be developed from the materials in the outline.
2. Suggested activities. This includes ideas for use by the teacher such as various types of plant collections, construction of simple keys, and plant photography. From these and others, the teacher can draw the activities best suited to the local situations.
3. Suggestions for evaluations. This includes a discussion of the various verbal tests and means of evaluation of scientific attitudes and interest through special projects and activities.
4. Suggested materials. This provides up-to-date sources of the variety of materials available to the teacher. Namely, these are films, preserved materials, charts, overhead transparencies, microscopic slides, and lantern slides.
5. Reference materials. This includes books, for the teacher's use and the student's use; periodicals, pamphlets and free materials.

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